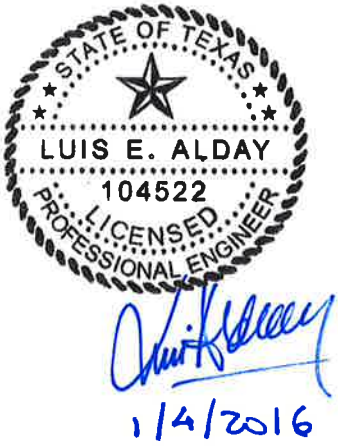
Drainage Master Plan



City of Copperas Cove

Prepared by:

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

PLANNING • ENGINEERING • PROGRAM MANAGEMENT

8911 N. Capital of Texas Highway, Building 2, Suite 2300 • Austin, Texas 78759
Phone: 512.338.4212
Firm No. 2614
http://www.lan-inc.com

Project # 120-11872-000

December 2016

Table of Contents

Executive Summary

The purpose of the Copperas Cove Drainage Master Plan (DMP) is to obtain an overall understanding of the City of Copperas Cove's current drainage infrastructure in order to develop a capital improvement plan (CIP) designed to reduce flooding risk. It includes a general identification and prioritization of drainage problem areas and development of conceptual solutions and cost estimates for the highest priority areas. The approach utilizes available existing information and models, complimented with field visits and desktop evaluation.

The top ranked projects and estimated project costs are listed below:

Table E1: Top Ranked projects and Estimated Project Costs

Rank	Project Number	Watershed	Location	Estimated Project Cost*
1	HC17	House	Drainage ditch along Oak Hill from cul-de-sac to intersection with Oak Hill Dr and Deer Flat Dr	$609,827
2	CC15	Clear	Culverts under FM 116 between Pleasant Ln and Tyler Dr (Meadow Brook)	$381,099
3	HC18	House	Intersection with Oak Hill Dr and Deer Flat Dr	Combined w/ HC17
4	HC15	House	Drainage ditch from Courtney Ln to N 17th St	$144,310
5	CC19	Clear	Suja Ln Culverts and drainage channels	$311,558
6	CC17	Clear	Shared Use Path behind 1612 Indian Camp Trail	$2313/$11,380
7	HC11	House	Culvert under 707 W Avenue D and ditches upstream to baseball field	$157,492
8	TR19	Turkey Run	Earthen drainage flume at 224 January St	$28,762
9	HC07	House	Drainage ditch on W Avenue B from Wagontrain Cir to Appaloosa Dr	$66,339
10	TR12	Turkey Run	809 Martin Luther King Jr Dr from Hardeman St to Williams St	$745,989
11	CC02	Clear	101 US 190; Storm Sewer Inlet under Auto Zone	$33,167/$74,050

* Two estimated project costs are listed when the solution includes two phases of work.

1.0 Introduction

In 2015, the City of Copperas Cove authorized Lockwood, Andrews, & Newnam, Inc. (LAN) to provide professional engineering services including the creation of a digital database of the existing stormwater infrastructure and a city-wide Drainage Master Plan (DMP). The DMP was developed from assessing and analyzing the condition of the existing drainage structures, identifying drainage problems in the city, prioritizing and developing a preliminary plan to address flooding issues. This drainage report summarizes the deliverables that include the existing stormwater infrastructure Geographic Information System (GIS) geodatabase, existing condition analyses and final priority CIP recommendations.

1.1 Study Area

The study area includes the city limits of Copperas Cove, which is located approximately 10 miles west of Killeen, TX and approximately 50 miles north of Georgetown, TX. The area encompasses about 18 square miles and has experienced a boost to the local economy and growth in population since the 1942 construction of Fort Hood Military Reservation located on the east side of the City. The majority of the city limits lie within Coryell County but portions of the city limits cross into Lampasas and Bell Counties. Copperas Cove is located at the localized high point of the surrounding area and has multiple watersheds. The study area is divided into five major drainage basins that are part of Clear Creek, House Creek, Taylor Creek, and Turkey Run watersheds. In general, stormwater flows from the center of the city out to the city limits. The study area is shown in Exhibit 1.

1.2 Purpose and Approach

The primary goal of the Drainage Master Plan is to help the City of Copperas Cove analyze the existing stormwater infrastructure, identify drainage problems, develop a prioritized list of problem areas and propose solutions that will address the identified problems. The second goal is to construct a digital database that contains the city's existing stormwater infrastructure so that the City has the ability to make future additions in order to have a comprehensive map of all of the stormwater infrastructure inside the city limits.

2.0 Data Collection

At the onset of the DMP, thorough data collection was conducted to gather the best available information for the project. As-built and GIS information was not available, therefore the primary sources of data regarding the existing stormwater system were previous drainage studies, Google Earth imagery, and field visits.

2.1 Desktop Evaluation

An online GIS application called "ArcGIS Collector" was used for the initial documentation of the spatial information of the city's stormwater infrastructures. Relevant spatial data was compiled from various sources for the project. The various sources of data include:

- 2011 LiDAR data obtained from Texas Natural Resources Information System (TNRIS) for Coryell, Lampasas and Bell County (LiDAR processed into 3' Digital Elevation Model [DEM] and 10' contours for design and analysis);
- Soils data obtained from NRCS Soil Survey;
- 2012 Orthoimagery obtained from Capital Area Council of Governments (CAPCOG) for Coryell, Lampasas and Bell Counties; and
- Other relevant map data (streets, parcels, stream centerlines, etc.) obtained from various sources.

LAN then obtained pertinent information from past drainage studies conducted within the City to begin the compilation of existing storm infrastructure. The Walker Partners 2010 City of Copperas Cove Drainage Study was used to document the major stream crossings and five major drainage basins included in the study. After obtaining relevant information from the Walker Study, Google Earth was used for initial identification of all visible existing stormwater infrastructure.

2.2 Field Visits

LAN dedicated a week to field visits to record and verify details of the identified infrastructure. In addition, the field visits were conducted to inspect specific problem areas and drainage features. The field visits also allowed for other infrastructure not visible with Google Earth to be identified and added to the database. Due to the limited time allowed for field visits, some features such as cross culverts, channels, storm sewers and outfalls were given higher priority to field verify than other features such as curb inlets. Therefore, not all stormwater infrastructure were verified and measured in the field.

2.3 Stormwater Geodatabase

After the preliminary map was field verified, the final digital inventory of the existing stormwater infrastructure was packaged into a GIS geodatabase. The geodatabase identifies approximately 700 nodes and over 11 miles of stormwater infrastructure. Pertinent information was attributed to each inlet, pipe and culvert such as type, length, size, material, etc. A level of knowledge was assigned to each storm link or node in the geodatabase. The storm infrastructure was classified under the categories ranging from most detailed to least detailed source of data: A, B, C or D. See the description of the levels of knowledge in Table 1 below. Tables 2 and 3 list the different feature details recorded for the links and nodes.

In addition to the feature details, related photos captured in the field were attached to the links and nodes. The photo categories include: general pictures, upstream or downstream looking at channel, upstream or downstream looking at face, or top of road.

Table 1: Level of Knowledge

Level	Description
A	Field Verified and Measured
B	Field Verified
C	Walker 2010 Study
D	Google Earth

Table 2: Feature Node Details

ID	Watershed	Node Type	Inlet Type	Opening Height	Invert Elevation	Number of Conduits
1	Clear Creek (CC)	Inlet	Area	Measured in inches	Measured in inches	1
2	House Creek (HC)	Manhole	Curb Inlet			2
3	Taylor Creek (TC)	Outfall	Drop Inlet			3
4	Turkey Run (TR)	Unknown	Grate			4
5			Headwall			5
etc.			Other			etc.
			Unknown			

Table 2: Feature Node Details Continued

Opening Shape	Material	Condition	Source	Level of Knowledge	Notes
Arch	Brick	Good	Field Visit Measured	A	Notes observed during field visits
Box	Concrete	Fair	Field Visit Verified	B	
Circle	Corrugated Metal	Poor	Walker 2010 Study	C	
Ellipse	Corrugated Plastic		Google Earth	D	
Oval	HDPE				
Other	Smooth Plastic				
Unknown	Steel				
	Other				
	Unknown				

Table 3: Feature Link Details

ID	Watershed	Number of Conduits	Conduit Type	Channel Type	Channel Shape	Culvert Shape	Culvert Material	Channel Depth
1	Clear Creek (CC)	1	Bridge	Concrete	Irregular	Arch	Brick	Measured in inches
2	House Creek (HC)	2	Channel	Concrete Flume	Rectangular	Box	Concrete	
3	Taylor Creek (TC)	3	Culvert	Earth	Trapezoidal	Circle	Corrugated Metal	
4	Turkey Run (TR)	4	Storm Sewer	Grass Lined	V	Ellipse	Corrugated Plastic	
5		5	Other	Rock Rip Rap	Other	Oval	HDPE	
etc.		etc.	Unknown	Other	Unknown	Other	Smooth Plastic	
				Unknown		Unknown	Steel	
							Other	
							Unknown	

Table 3: Feature Link Details Continued

Rise	Span	Culvert Length	Slope	US/DS End Treatment	US/DS Invert Elevation	Condition	Source	Level of Knowledge	Notes
Measured in inches	Measured in inches	Measured in inches	(ft/ft)	Headwall	Measured in inches	Poor	Field Visit Measured	A	Notes observed during field visits
				Mitered		Fair	Field Visit Verified	B	
				Projecting		Good	Walker 2010 Study	C	
				SET			Google Earth	D	
				Other					
				Unknown					

3.0 Existing Conditions Evaluation Methodology

LAN developed integrated Infoworks ICM one-dimensional-two-dimensional (1D-2D) models to understand the complex drainage issues observed within the region. 2D models offer unique insight into how overland stormwater conveyance is tightly coupled to and influenced by the subsurface storm sewer system and roadside ditch conveyance system. The 1D-2D distinction refers not to actual physical dimensions, but to the number of directions in which flow is analyzed in the model. For a one-dimensional element such as a pipe, fluid motion equations are solved in one direction along the length of the pipe. For a two-dimensional element such as a surface, fluid motion equations are solved through a triangular grid system along multiple directions across the terrain. The performance of the stormwater infrastructure within the region was evaluated for various storm frequencies and found to be functionally deficient in several locations.

3.1 Hydrology

Over 33 square miles of terrain was divided into North, South, East, and West quadrants and modeled in InfoWorks. This division was necessary to run the models within a reasonable amount of time. The North quadrant corresponds to the House Creek basins, the South quadrant corresponds to the Clear Creek basin, the East quadrant corresponds to the Turkey Run basin, and the West quadrant corresponds to the Taylor Creek basin. These drainage basins were delineated based on 2011 LiDAR data.

3.1.1 Roughness Coefficients

A roughness coefficient of 0.06 corresponding to the City of Austin's "Transportation" land use classification was applied uniformly to streets and ROW areas. Based on parcel lines, developed areas and open spaces were assigned a roughness coefficient of 0.12 to account for buildings and trees.

3.1.2 Rainfall Data

All models were evaluated for three storm events: the 25-, 10- and 2-year storms. A "25-year" storm event is one that is likely to occur once every 25 years, or that has a 4 percent chance of occurring in any given year. LAN used NRCS frequency storms generated by InfoWorks ICM and applied rainfall directly to the terrain mesh grid, also with the goals of model simplification and decreased run time in mind. 24-hour rainfall depths for the three NRCS Type II storms were taken from TxDOT's program for determining Intensity-Duration Frequency of Annual Precipitation Maxima. This program generates maximum rainfall depths for various storm durations and non-exceedance probabilities based on the latitude and longitude of the location of interest.

3.2 Hydraulics

The 1D model storm network consists of nodes, open channels, and conduits which represent storm sewer inlets, outfalls, culverts, bridges, and storm sewer conduits. The hydraulic

network was developed from site visit data, previously developed GIS information, and aerial imagery. Where no other information was available, pipe inverts were populated from downstream to upstream based on appropriate velocity and ground cover limitations.

The existing conditions 2D model results are included in Appendix C.

4.0 Capital Improvement Identification and Prioritization

4.1 Problem Area Identification

The 2016-2020 CIP and remaining 2015-2019 CIP drainage projects were used for preliminary identification of existing problem areas. Problem areas were also identified through the field visit and through an inventory of citizen complaints. The 2D modeling results were then analyzed to identify a total of 71 problem areas.

4.2 Criteria Prioritization

Projects were ranked using criteria which consider:

- Structures at Risk (the number of structures and/or roads at risk);
- Street Flooding (the classification of roads affected by the problem);
- Erosion & Sedimentation risk;
- the number of Properties at Risk;
- the Availability of External Funding;
- probable Project Cost;
- CIP Overlap (if a problem area has already been identified by a CIP);
- the number of Maintenance Work Orders received regarding the area; and
- the Method by which the problem area was identified (citizen, City, site visit, or model results).

These criteria were then weighted by LAN using a customized pairwise process, allowing each criterion to be weighed against the other based on a scale of 1 to 3. A score of 3 means that one criterion is considered more important than the other, a score of 2 means that the criteria are of the same importance, and a score of 1 means that the criterion is considered less important than another. The criteria being ranked are listed horizontally, and the criteria they are being ranked against are listed vertically.

The results of the pairwise process are shown in Table 4. For example, the importance of the number of Structures at Risk was compared with the importance of Street Flooding (affected road classification). As seen in Table 4, the number of Structures at Risk was determined to be more important than Street Flooding due to the need to provide safe ingress/egress for residents and emergency responders. Thus, Structures at Risk received a score of 3 in this comparison.

Table 4: Pairwise Evaluation Criteria Ranking Results

Criteria	Structures at Risk	Street Flooding	Erosion & Sedimentation	Properties at Risk	Availability of External Funding	Project Cost	CIP Overlap	Maintenance Work Orders	Identification Method	Sum	Rank
Structures at Risk		3	3	3	3	3	3	3	3	**24**	1
Street Flooding	1		2	3	3	3	3	3	3	**21**	2
Erosion & Sedimentation	1	2		3	3	3	3	3	3	**21**	2
Properties at Risk	1	1	1		2	2	2	3	3	**15**	5
Availability of External Funding	1	1	1	2		1	2	2	2	**12**	7
Project Cost	1	1	1	2	3		2	3	3	**16**	4
CIP Overlap	1	1	1	2	2	2		3	2	**14**	6
Maintenance Work Orders	1	1	1	1	2	1	1		2	**10**	9
Identification Method	1	1	1	1	2	1	2	2		**11**	8

Based on the Pairwise comparison table above, Table 5 shows the evaluation criteria and the assigned weighting value in order from 1 to 9. The final criteria weights and ranking shown below were approved by the City.

Table 5: Pairwise Evaluation Criteria Ranking Results

Rank	Criteria	Weight
1	Structures at Risk	24
2	Street Flooding	21
2	Erosion & Sedimentation	21
4	Project Cost	16
5	Properties at Risk	15
6	CIP Overlap	14
7	Availability of External Funding	12
8	Identification Method	11
9	Maintenance Work Orders	10

4.3 Project Scoring

After the criteria were weighted, LAN developed a thorough scoring system for each criterion. The goal was to establish descriptions that provide consistent scoring results and would allow future projects to be scored by the same system if necessary. The scoring choices for each criterion are described below:

Structures at Risk – This criterion considers the number of currently developed structures and/or roadways within the problem area that are subject to flooding or flood-related damage. Areas with structures at risk that are considered critical receive extra points. "Critical facilities" include government buildings, fire stations, the police station, water treatment plants, water wells, and water storage tanks.

Number of Structures and /or Roads at Risk	Points
> 5	8
3 - 5	6
1 - 2	4
None	0

+2 points if a critical facility is included

Street Flooding – Heavy rainfall creates hazardous conditions on roadways, and effectively removes flooded segments from the transportation network. Serious traffic and safety problems can result from interrupting the ability to move through an area, particularly toward critical facilities. "Critical facilities" include government buildings, fire stations, the police station, water treatment plants, water wells, and water storage tanks. Project scoring is based on the functional classification of the roadway of interest, with extra points added if the road is considered a primary route to a critical facility, or if it is the sole means of access to public or private properties.

Highest Classification of Affected Roads	Points
Major Arterial	4
Minor Arterial	3
Collector	2
Local	0

+3 points if primary route to critical facility

+3 points if sole route for ingress/egress to properties

Erosion & Sedimentation – The City of Copperas Cove has several areas prone to severe erosion; this criterion assesses the severity of the risk Erosion and Sedimentation pose within the problem areas. Certain soil types are more prone to erosion than others; the erosion can destabilize drainage infrastructure as well as other infrastructure. The eroded particles are deposited elsewhere as sediment, which can lead to clogged drainage infrastructure and other problems.

Type of Risk	Points
Risk to public safety	10
Risk to infrastructure	7
Risk to drainage features	4
None	0

Properties at Risk – This criterion counts the number of individual properties that are subject to flooding or at risk of flood-related damage within the project area.

Number of Properties	Points
> 5	10
3 - 5	7
1 - 2	4
None	0

Availability of External Funding – While cities are able to fund some capital improvement projects, external funding can also be made available through a public-private-developer partnership, TxDOT or county funding, grants through various agencies, and donations. Project scoring is based on the likelihood that external funding is available to leverage use of City funds.

Likelihood of external funding	Points
Very Likely	10
Somewhat Likely	5
Not Likely	0

Project Cost – Project scoring is based on a preliminary estimate of project cost with lower-cost projects receiving higher scores due to the limitations of funding larger projects. A project receives the maximum score if it can be completed by City staff without the need for a public bidding process.

Project Cost	Points
City Staff	10
Less than $199,999	8
$200,000 - $499,999	5
$500,000 - $999,999	3
More than $1,000,000	0

CIP Overlap – A project receives extra points for having been identified through one of the previous CIP's, or by being located within close proximity to a previously identified CIP.

Does Project overlap with Other CIP Projects?	Points
Direct Overlap	10
Close to Other Project	5
No Overlap	0

Maintenance Work Orders – Projects can be identified as on-going maintenance issues due to erosion, debris accumulation, or repeated repairs. This criterion awards points for the potential reduction of maintenance costs by implementing a long-term solution. Points are awarded to projects with more history of maintenance needs based on the number of work orders issued.

Number of Work Orders	Points
> 5	10
3 - 5	7
1 - 2	4
None	0

Identification Method – Projects are ranked higher if the problem area was identified by taxpayers or by the City of Copperas Cove to give due credit to local knowledge of the city. If a problem area was identified through field investigation or 2D modeling, it receives fewer points.

Who Identified the Issue?	Points
Citizen	10

City	8
Site Visit	4
Modeling	4

4.4 Project Ranking

Each project was scored using the nine criteria and then multiplied by the corresponding criteria weights to develop the total score. The 71 projects were ranked using the total score. Table 6 lists the top ranked projects. Exhibits 2-5 show the 25-year storm existing conditions model results with the top ranked projects.

Table 6: Top Ranked Projects

Rank	Project Number	Watershed	Location
1	HC17	House	Drainage ditch along Oak Hill from cul-de-sac to intersection with Oak Hill Dr and Deer Flat Dr
2	CC15	Clear	Culverts under FM 116 between Pleasant Ln and Tyler Dr (Meadow Brook)
3	HC18	House	Intersection with Oak Hill Dr and Deer Flat Dr
4	HC15	House	Drainage ditch from Courtney Ln to N 17th St
5	CC19	Clear	Suja Ln Culverts and drainage channels
6	CC17	Clear	Shared Use Path behind 1612 Indian Camp Trail
7	HC11	House	Culvert under 707 W Avenue D and ditches upstream to baseball field
8	TR19	Turkey Run	Earthen drainage flume at 224 January St
9	HC07	House	Drainage ditch on W Avenue B from Wagontrain Cir to Appaloosa Dr
10	TR12	Turkey Run	809 Martin Luther King Jr Dr from Hardeman St to Williams St
11	CC02	Clear	101 US 190; Storm Sewer Inlet under Auto Zone

**Projects 1 and 3 (HC17 and HC18) are in the same location and were treated as one project, thus 11 projects are included as the top ranked projects.

5.0 Solution Development

Conceptual solutions were developed for the top ranked projects using the most appropriate combinations of 2D modeling, HY-8, and/or FlowMaster; these solutions are described within this section and summarized in the cut sheets in Appendix B, including final cost estimates. Unit prices are based on the TxDOT Waco District average low bid unit prices published on August 31, 2016. If an item had no average low bid unit price listed or it was judged that the listed price was too low, the item's price was inferred accordingly.

The City of Copperas Cove Drainage Criteria Manual specifies that all stormwater infrastructure must be designed to intercept, contain, and transport all runoff from the 25-year frequency storm. It can be difficult to retrofit existing neighborhoods to meet current design criteria for extreme storm events in all aspects and in all areas without substantial reconstruction of the entire neighborhood. It is for this reason that the recommended improvement projects seek to meet current design criteria, however it is not achieved for all areas. The improvements recommended offer a benefit over existing conditions and provide a higher level of service; however, ponding exceeds drainage criteria in some locations due to the severe challenges of topography and assumptions of fully developed conditions assumptions in some areas.

5.1 Projects 1 and 3: HC17 and HC18 (Oak Hill Phase 1A & 1B)

The top ranked project is located in House Creek basin at the drainage ditch along Oak Hill Drive from the cul-de-sac to the intersection with Oak Hill Drive and Deer Flat Drive. Citizens identified street and property flooding and debris build-up on the road and in the adjacent channel. It was confirmed that the channel next to Oak Hill had far from sufficient capacity and that the maximum channel graded within the existing ROW would carry only half of the 25-year storm runoff. Thus, it is recommended that the City acquire 10 feet of ROW on the east sides of Oak Hill and Deer Flat Drives, upgrade the culvert southeast of the intersection and the driveway culverts upstream, and re-grade the channels next to Oak Hill and Deer Flat Drives to convey the 25-year storm. This will alleviate the street flooding along Oak Hill and the flooding of the properties west of the cul-de-sac as well as the property northeast of Deer Flat Drive. The estimated cost of this project is $609,827.

Runoff from the channel along the Oak Hill cul-de-sac flows across the property northeast of Deer Flat Drive to a stock pond on the north side of that property under existing conditions. It is proposing to grade a channel along Deer Flat Drive that outfalls to the same stock pond as under existing conditions to avoid causing an adverse impact to this property owner. Pending discussions with the property owner regarding right-of-way (easements) versus increased flow across the property, this portion of the project could be forgone and the project cost would decrease accordingly.

5.2 Project 2: CC15 (Meadow Brook)

This project is located in the Clear Creek watershed at FM 116 between Pleasant Lane and Tyler Drive. Sediment build-up was identified in the culverts and severe erosion has occurred

upstream, including an exposed utility line. LAN confirmed that the culverts under FM 116 have sufficient capacity for the 25-year storm but estimated the velocity in the channel upstream to exceed 20 feet per second for the 10-year storm. Since the City has implemented a channel liner solution consisting of rock riprap with only short-term success, it is recommended that the City implement a natural channel design solution consisting of grade control structures placed across the channel flow line. This will create a series of steps and pools within the channel to control velocity and provide vertical stability; the estimated cost of this project is $381,099. It is also recommended that the exposed utility line upstream be encased in concrete for protection and that the sedimentary debris be removed from the FM 116 culverts.

5.3 Project 4: HC15 (Courtney Lane)

This project is located in House Creek watershed at the drainage ditch from Courtney Lane to N 17th Street. City staff and model results identified severe erosion and sedimentation problems within the channel. It was confirmed that the culverts under Courtney Lane have sufficient capacity for the 10-year storm but there is not sufficient lateral space to add another reinforced concrete box (RCB) for increased capacity. The velocity in the channel upstream is estimated to exceed 18 feet per second for the 10-year storm. Similar to Project 2, It is recommended that the City implement a natural channel design solution consisting of grade control structures placed across the channel flow line. This will create a series of steps and pools within the channel to control velocity and provide vertical stability. The estimated cost of this project is $144,310.

5.4 Project 5: CC19 (Suja Lane)

This project is located in Clear Creek watershed at the Suja Lane. Citizens and City staff identified street and property flooding at the culverts near the end of the street. It was confirmed that the 2-year storm flow in this area is over 300 cfs, while the two 18-inch diameter pipe culverts have a combined capacity of less than 40 cfs. It is recommended that the main channel be re-graded from elevation 1118 to 1104 to a 35-ft top width, 4-ft deep section with 3 to 1 horizontal to vertical side slopes and 10-ft bottom width to carry the 10-year storm. If the 18-inch pipe to the south is replaced with four 4-ft by 4-ft RCBs the culvert will safely pass the 2-year storm. This solution will alleviate the street and property flooding in the area and the estimated cost of this project is $311,558.

If a new development is to be built upstream, the City will require detention to mitigate potential downstream impacts. An alternative solution at this site might be to contribute a portion, or all, of these funds to a joint use detention facility upstream and over-detain stormwater runoff to reduce flooding. Additional study is required to determine the effectiveness at Suja Lane.

5.5 Project 6: CC17 (Indian Camp Trail)

This project is located in Clear Creek watershed at the shared use path (SUP) behind 1612 Indian Camp Trail. Citizens, City staff, and LAN staff identified flooding and algae growth on the SUP caused by groundwater seepage and low flow from the storm drain apron; water from the backyard at 1612 Indian Camp Trail may be seeping out from beneath the retaining wall and also contributing to the algae growth. The solution to this problem consists of two steps, the first of which is to remove the algae growth and seal the concrete with a water-repelling sealant including an anti-skid additive. If the first step does not alleviate the safety hazard, it is recommended that a v-notch concrete ditch be installed from the backyard at 1612 Indian Camp Trail and at the joint between the baffle apron and SUP parallel to the SUP, eventually turning across the SUP, and out-falling to the creek. The portion of the v-ditch perpendicular to the SUP will be covered with a metal grate. The estimated cost of Phase 1 of this project is $2,313, and the estimated cost of Phase 2 is $11,380.

5.6 Project 7: HC11 (Avenue D)

This project is located in House Creek watershed at the culvert under 707 W Avenue D and the ditch upstream to the baseball field. City staff and model results indicate that street flooding at the culvert crossing, upstream channel erosion, and flooding at the baseball field. It was confirmed that the two 6-feet by 4-feet RCBs under Avenue D cannot safely pass the 10-year storm and it is recommended that a 4-ft wide by 4-ft tall RCB be installed next to the existing culverts to safely pass the 10-year storm. This will alleviate the street flooding on Avenue D without causing an adverse impact downstream of the railroad. The channel next to the soccer field can be rehabilitated by re-grading the cross-section to a 45-feet top width, 25-feet bottom width, 2.5-feet deep trapezoid with 4 to 1 horizontal to vertical side slopes and adding a soil retention blanket. The estimated cost of this project is $157,492.

5.7 Project 8: TR19 (January Street)

This project is located in Turkey Run watershed at the earthen drainage flume next to 224 January Street. Citizens identified property flooding and erosion of the flume between homes. LIDAR data indicates that there is a high point along the flow line of the flume close to the street. It is recommended that the flume be re-graded to a 10-ft wide, 0.5-ft deep section with a consistent longitudinal slope and lined with concrete. This will alleviate the flooding and erosion and achieve design uniformity with other flumes between properties in the area. The estimated cost of this project is $28,762.

5.8 Project 9: HC07 (Avenue B)

This project is located in House Creek watershed at the drainage ditch on W Avenue B from Wagontrain Circle to Appaloosa Drive. Citizens identified localized flooding due to insufficient drainage ditch conveyance and inlet blockage, including the grate inlets between Wagontrain and Rodeo Circle being covered in gravel from recent construction. Based on LiDAR data, the roadside ditch from Appaloosa Drive to the grate inlet west of Wagontrain Circle is almost

non-existent, and the culvert under Wagontrain Circle is undersized. It is recommended that the roadside ditch be re-graded to a 12-ft top width V-ditch with 3:1 side slopes from Appaloosa to Wagontrain. The pipe that carries water under Wagontrain to the grate inlet should be upgraded to two 24-inch reinforced concrete pipes (RCPs). This will alleviate the street flooding on W Avenue B. The estimated cost of this project is $66,339.

5.9 Project 10: TR12 (MLK)

This project is located in Turkey Creek watershed near 809 ML King Jr Drive from Hardeman Street to Williams Street. Citizens, City and LAN staff identified street and property near the channel going from MLK to US 190 and US 190 to the railroad. Water flows from south to north, in an area that is fully developed, making a detention solution not feasible. It was confirmed that the culverts under MLK do not have sufficient capacity for the 10-year storm, and that a lack of conveyance in the channel downstream is causing the storm sewer system on MLK to surcharge. Surcharging means that instead of a storm sewer system capturing water and conveying it downstream, the system is actually backing up and discharging water at ground level under extreme flood conditions. It is recommended that an additional 20-foot inlet be installed near MLK and Hardeman and that the pipe connecting this inlet and the existing inlet downstream to the main trunk line be upgraded to a 5-ft x 3-ft RCB. It is also recommended that the two 36-inch pipes perpendicular to MLK be replaced with two 5-ft x 3-ft RCBs. Finally, the earthen channels from MLK to US 190 and US 190 to the railroad should be re-graded to 22-feet top width, 10-feet bottom width trapezoidal concrete sections with 1 to 1 horizontal to vertical side slopes. These solutions combined will alleviate the street and property flooding on MLK and US 190 and prevent the storm sewer system from surcharging; the estimated cost of this project is $745,989.

5.10 Project 11: CC02 (US 190)

This project is located in Clear Creek watershed at the storm sewer inlet in front of Auto Zone at 101 US Highway 190. City and LAN staff identified erosion and sedimentation in the channel in front of Auto Zone where the Main Street storm sewer system discharges through a 5-ft by 4-ft RCB. Much of this flow should be captured by the 36-inch RCP flowing south to the channel behind Phyllis Drive; however, the RCP has no headwall, the slope around the RCP is severely eroded, and the area between the RCB and RCP is filled with sediment. It is recommended a two-phase solution for this project, the first of which is to place a headwall with wingwalls around the 36-inch RCP, remove the sediment from the RCB outfall, and re-grade the area between the RCB and RCP, adding a concrete pilot channel between the two.

If this does not alleviate the flooding in front of the store, the second phase of the project would be to replace the driveway culverts at the industrial complex on US 190 with two 24-inch RCPs and re-grade all roadside ditches from Leonhard Street to the channel south of the industrial complex. This will improve the street and channel flooding along US 190.

The estimated cost of Phase 1 of this project is $33,167 and the estimated cost of Phase 2 is $74,050.

6.0 Conclusions and Recommendations

Through this study, LAN was able to gain a comprehensive understanding of the limitations and deficiencies of the drainage systems that serve the City of Copperas Cove and to generate recommendations of improvement projects that are both functionally efficient and financially effective. The proposed improvements will reduce flood risk and mitigate losses due to flooding in a cost-effective manner without causing adverse impacts to areas downstream.

Because these projects are retrofit projects in developed areas it was difficult to meet current design criteria for extreme storm events in all aspects and in all areas without substantial reconstruction of entire neighborhoods. The proposed solutions offer benefits over existing conditions and provide higher levels of service; however, ponding exceeds drainage criteria in some locations due to topographic challenges and fully developed conditions of nearby neighborhoods.

Appendix A – Exhibits

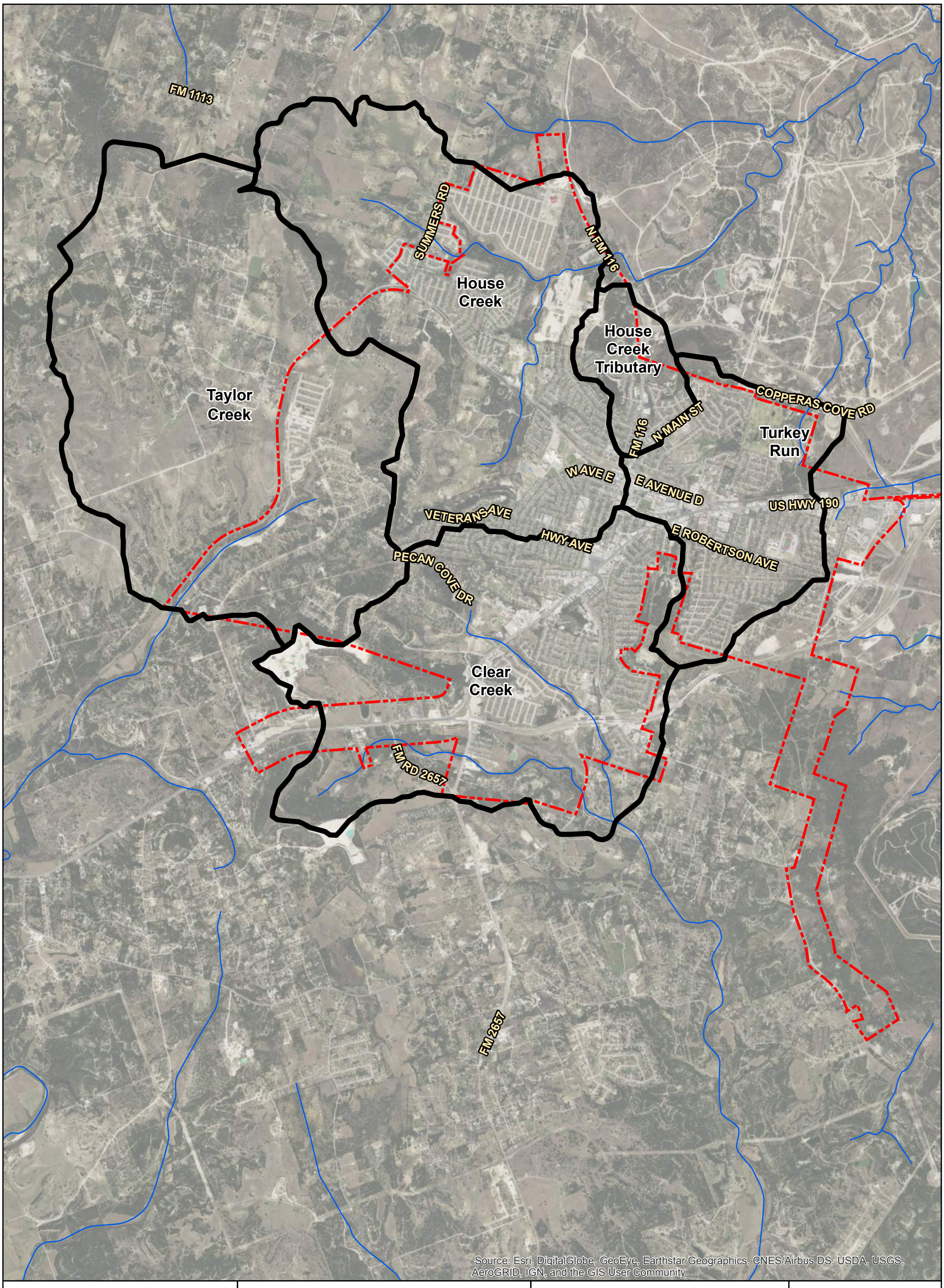
Exhibit 1 – Study Area

Exhibit 2 – House Creek

Exhibit 3 – Clear Creek

Exhibit 4 – Turkey Run

Exhibit 5 – Taylor Creek



LEGEND

- City Limit
- Major Basins
- Rivers and Streams

COPPERAS COVE
MASTER DRAINAGE PLAN

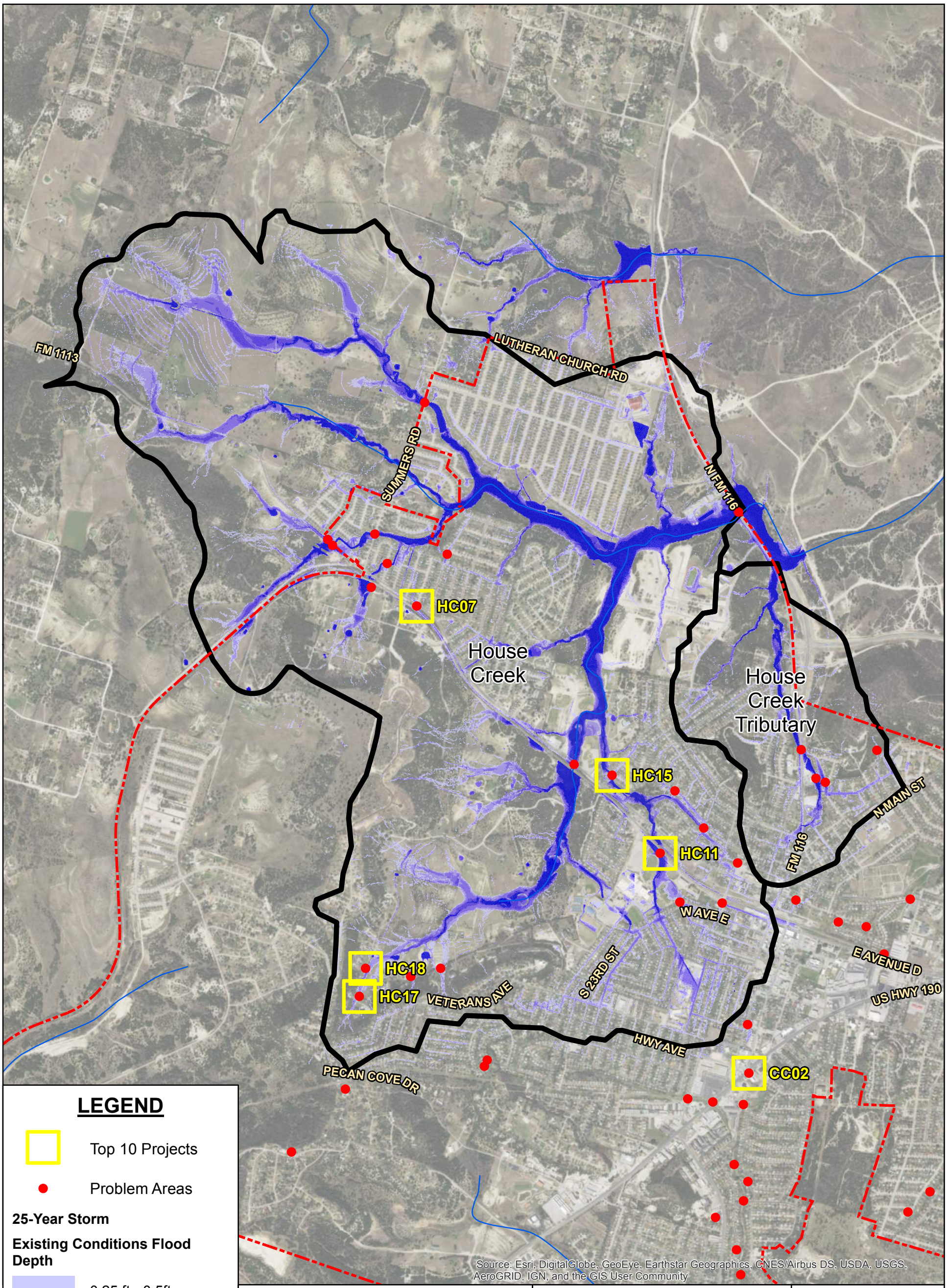
Exhibit 1:
Study Area

December 2016

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

0 0.5 1
MILES



LEGEND

- Top 10 Projects
- Problem Areas

25-Year Storm

Existing Conditions Flood Depth

- 0.25 ft - 0.5ft
- 0.5 ft - 1 ft
- 1 ft - 2 ft
- 2 ft - 3 ft
- > 3 ft
- Rivers and Streams

COPPERAS COVE MASTER DRAINAGE PLAN

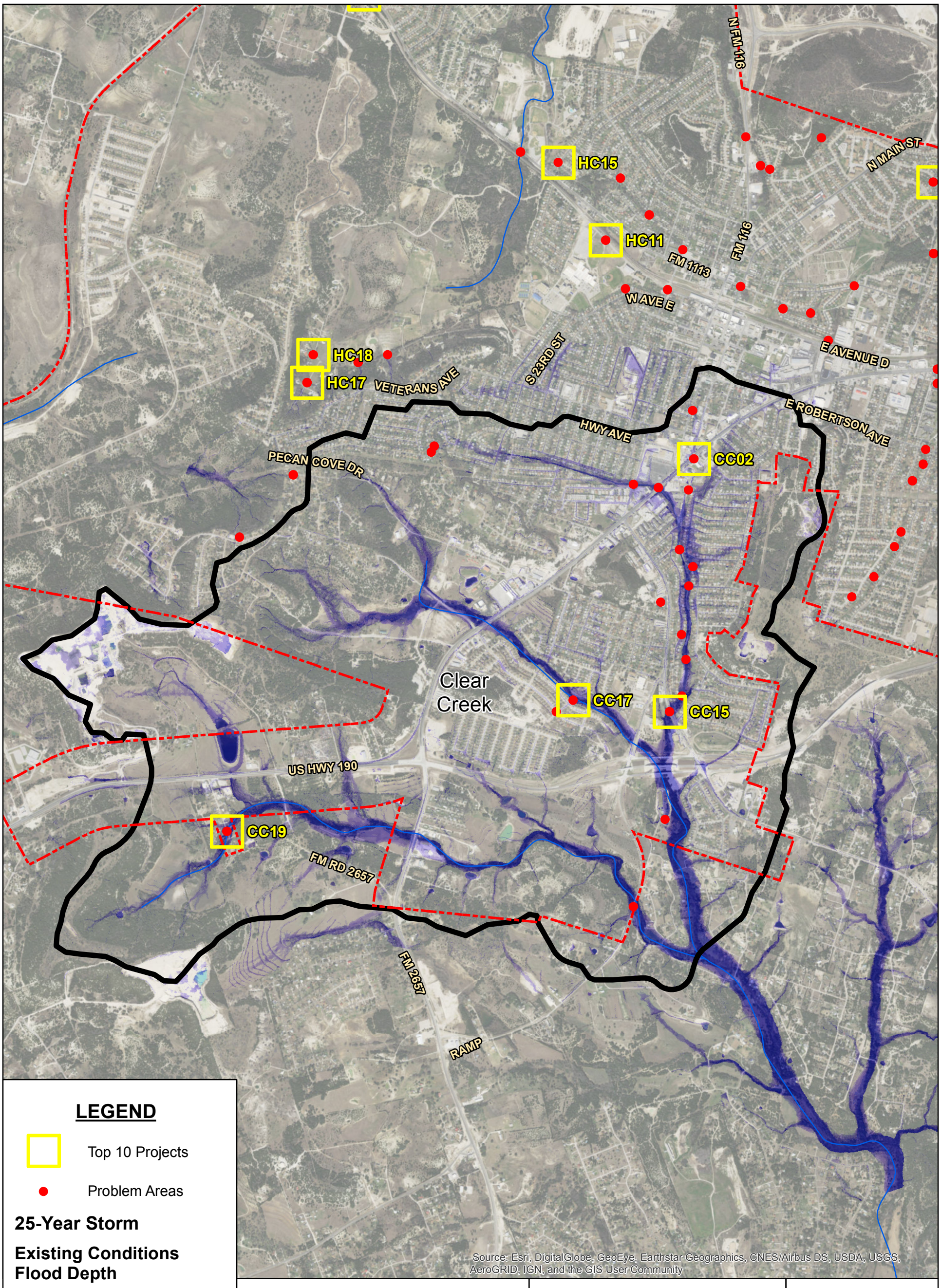
Exhibit 2:
House Creek

December 2016

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

0 0.25 0.5
MILES



LEGEND

- Top 10 Projects
- Problem Areas

25-Year Storm

Existing Conditions Flood Depth

- 0.25 ft - 0.5ft
- 0.5 ft - 1 ft
- 1 ft - 2 ft
- 2 ft - 3 ft
- > 3 ft
- Rivers and Streams

COPPERAS COVE MASTER DRAINAGE PLAN

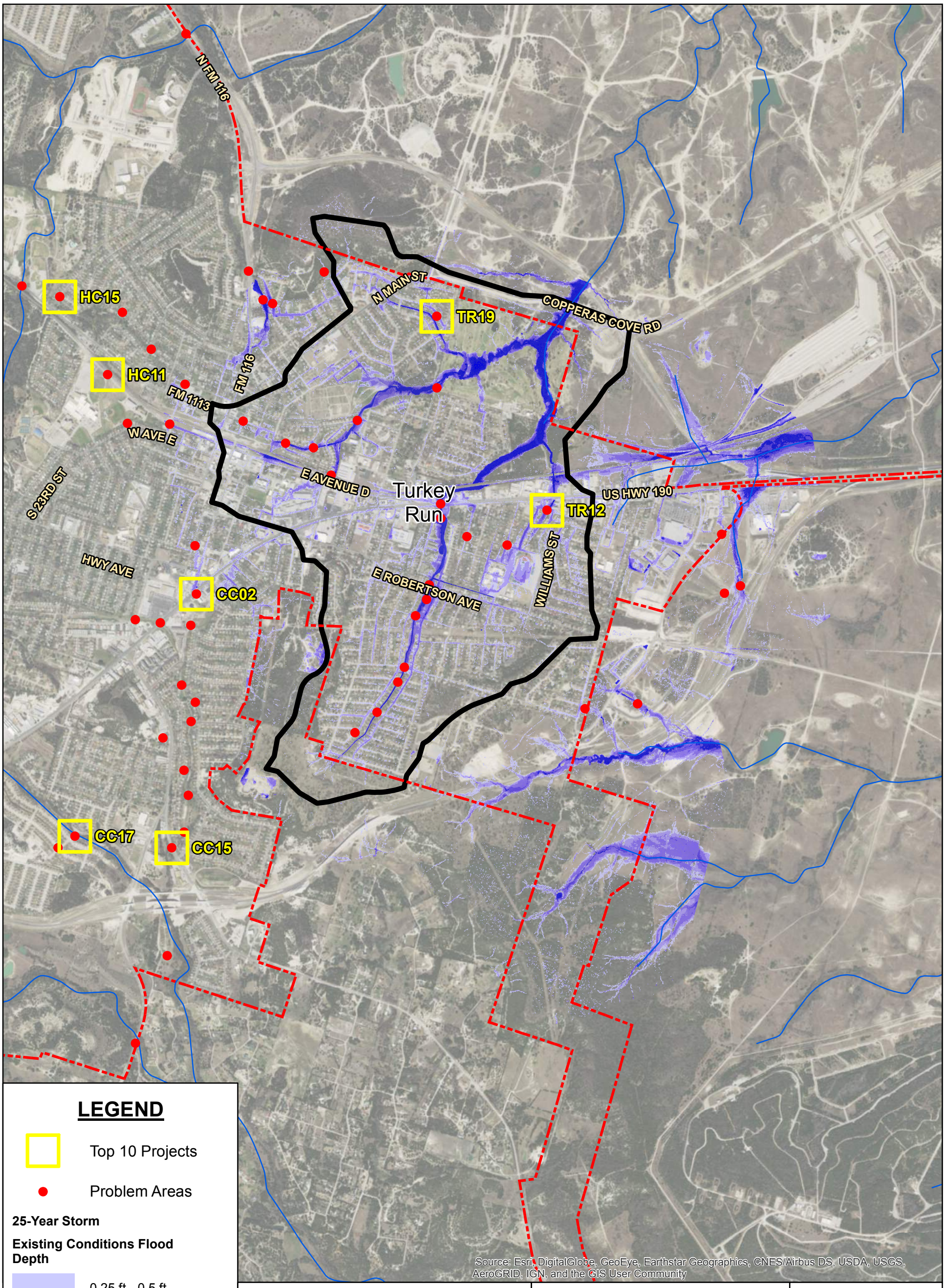
Exhibit 3:
Clear Creek

December 2016

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

0 0.25 0.5
MILES



LEGEND

- Top 10 Projects
- Problem Areas

25-Year Storm

Existing Conditions Flood Depth

- 0.25 ft - 0.5 ft
- 0.5 ft - 1 ft
- 1 ft - 2 ft
- 2 ft - 3 ft
- > 3 ft
- Rivers and Streams

COPPERAS COVE MASTER DRAINAGE PLAN

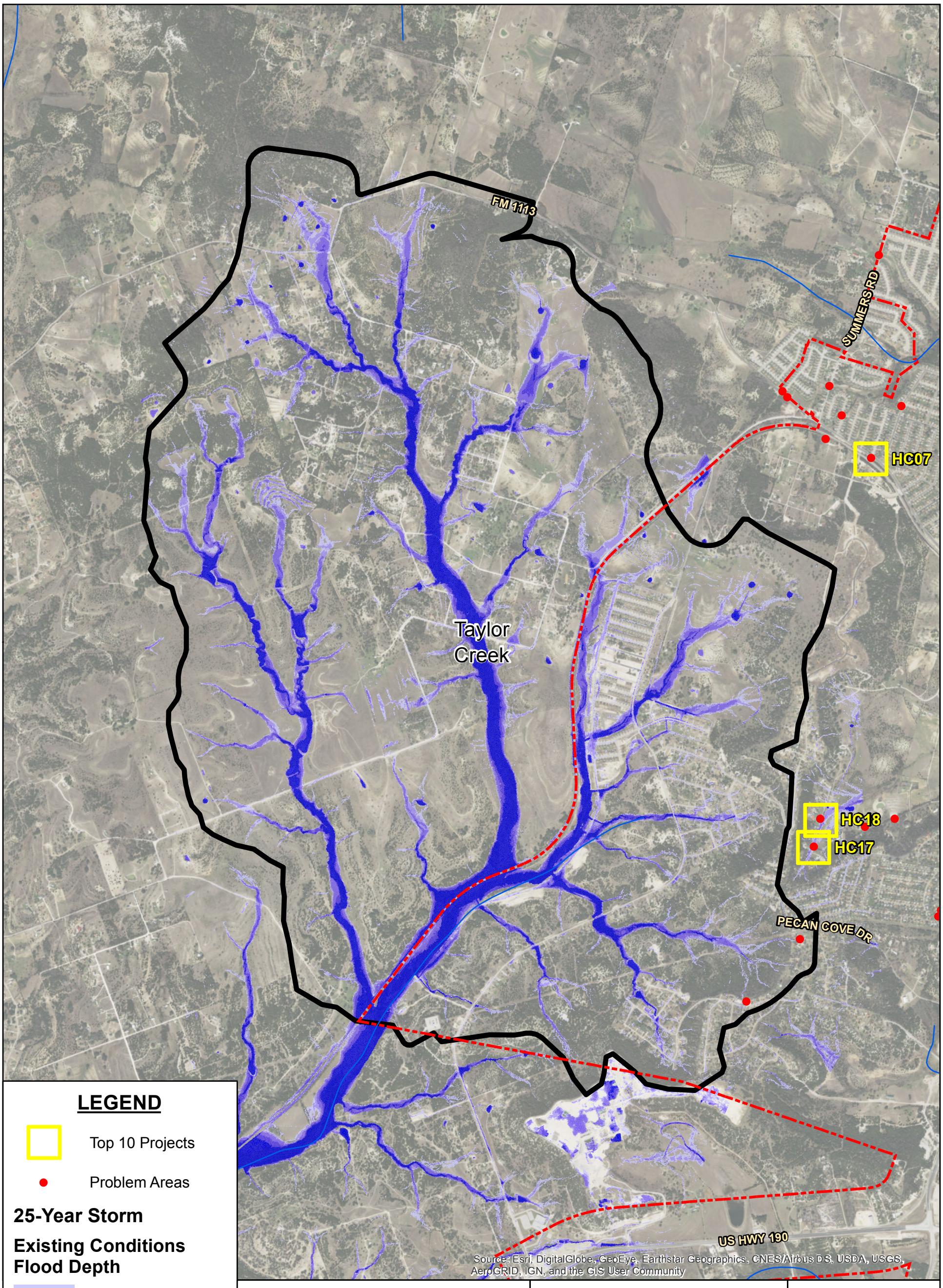
Exhibit 4: Turkey Run

December 2016

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

0 0.25 0.5
MILES



LEGEND

- Top 10 Projects
- Problem Areas

25-Year Storm

Existing Conditions Flood Depth

- 0.25 ft - 0.5ft
- 0.5 ft - 1 ft
- 1 ft - 2 ft
- 2 ft - 3 ft
- > 3 ft
- Rivers and Streams

COPPERAS COVE MASTER DRAINAGE PLAN

Exhibit 5:
Taylor Creek

December 2016

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

0 0.25 0.5
MILES

Appendix B – Cut Sheets

Project 01 - HC17 (Oak Hill Phase 1A, Oakhill)

HC18 (Oak Hill Phase 1B, Deer Flats)

Project 02 - CC15 (Meadow Brook)

Project 03 - HC 15 (Courtney Lane)

Project 04 - CC19 (Suja Lane)

Project 05 - CC17 (Indian Camp Trail Shared Use Path)

Project 06 - HC11 (Avenue D)

Project 07 - TR19 (January Street)

Project 08 - HC07 (Avenue B)

Project 09 - TR12 (MLK)

Project 10 - CC02 (US 190)

December 22, 2016

City of Copperas Cove

City of Copperas Cove - Master Drainage Plan
Preliminary Assessment

Project Number: HC17 (Oakhill) and HC18 (Deer Flats)

Project Name: Oak Hill Improvements Phase 1A (Oakhill)
Oak Hill Improvements Phase 1B (Deer Flats)

Description: Citizen Identified - Street, property flooding, debris build up-in channel and on roadway. 24" Culvert capacity = 20 cfs, < 10-year storm (see photo), ROW capacity = 130 cfs < 25-year storm

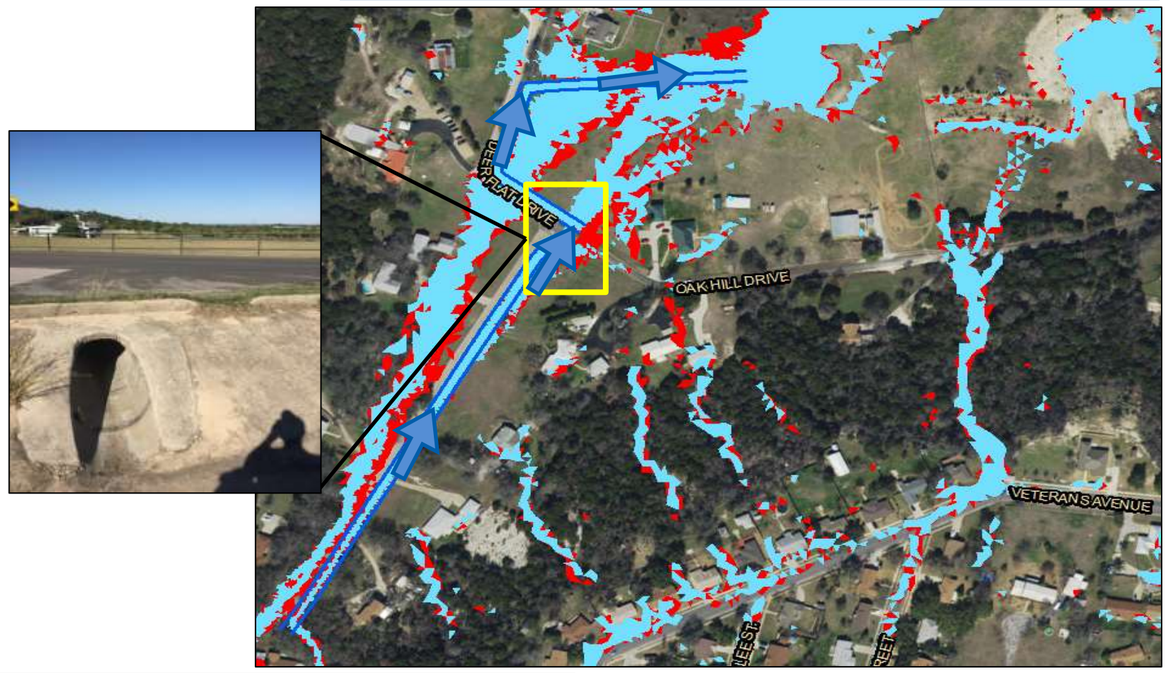
Solution:
Acquire 10 feet of ROW on East sides of Oak Hill and Deer Flat Drives
Replace culvert southeast of intersection with two 6x3 RCBs to safely pass 25-year storm
Replace 3 driveway culverts with one 5x3 RCB each
Re-grade channels to 25 ft top width, 5 ft bottom width, 4:1 side slopes from elevation 1184 to elevation 1133 and elevation 1132 to elevation 1110 to carry 25-year storm plus freeboard

Results: Alleviate street flooding and flooding of properties west of Oak Hill cul-de-sac, as well as property northeast of Deer Flat Dr

Problem Type: Flooding

Location: North quadrant; Drainage ditch along Oak Hill from back of cul-de-sac to intersection with Oak Hill Dr and Deer Flat Dr

Sources of Water: House Creek basin; Veterans Ave neighborhood



Cost Analysis:

TxDOT Spec No.	Item Description	Quantity	Unit	Unit Price	Total Price
	MOBILIZATION	1	LS	$50,000.00	$50,000.00
	EASEMENT/ROW ACQUISITION	1	LS	$25,000.00	$25,000.00
	CULVERT CROSSING (STREET REPAIR)	2,200	SF	$20.00	$44,000.00
110 6002	EXCAVATION (CHANNEL)	2,917	CY	$14.15	$41,270.83
164 6005	BROADCAST SEED (PERM) (URBAN) (SANDY)	8,167	SY	$0.97	$7,921.67
432 2002	RIPRAP (CONC)(5 IN)	167	CY	$550.00	$91,666.67
462 2007	CONC BOX CULV (5 FT X 3 FT)	66	LF	$220.00	$14,520.00
462 6010	CONC BOX CULV (6 FT X 3 FT)	70	LF	$300.00	$21,000.00
467 61XX	SET (TY I)(HW=3FT)	10	EA	$6,000.00	$60,000.00
	SWPPP	1	LS	$5,000.00	$5,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$1,000.00	$1,000.00
	ENGINEERING AND SURVEY	1	LS	25%	$90,344.79
				Total Funding for Solution	$451,723.96
				35% Contingency	$158,103.39
				TOTAL	**$609,827.34**

* 10-Year Storm Inundation, Existing vs Proposed Results

Additional Potential Costs:
(not included in Cost Analysis)

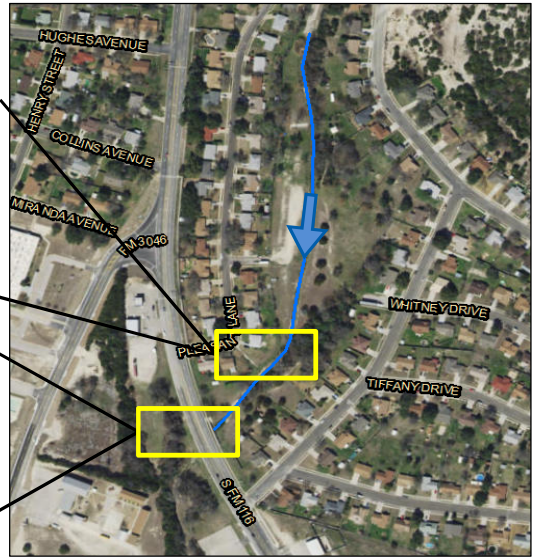
Environmental / Permitting	n/a
Easement Acquisition/Coordination	Y
Utility Adjustments	n/a

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

City of Copperas Cove - Master Drainage Plan
Preliminary Assessment

Project Number:	CC15	**Problem Type:**	Erosion
Project Name:	Meadow Brook	**Location:**	South quadrant; Culverts under FM 116 between Pleasant Ln and Tyler Dr
Description:	Site Visit Identified - Culverts under FM 116 filled with sediment from channel erosion (see photo). The crossing at FM116 inlcudes two 8x4 and five 9x5 culverts which pass 25-year storm Channel experiences extremely high velocity for 10-year storm Upstream portion of channel is concrete-lined at 1% slope, downstream portion (location of this project, shown in blue) is unlined at 2% slope	**Sources of Water:**	Clear Creek basin
Alternative #1:	Natural step-pool channel design Place grade control structures at various points along the channel from outfall near Hughes Ave to culvert under S FM 116 Initiate seasonal mow schedule to allow natural riparian buffer to form along channel banks to reduce potential for erosion Place concrete encasement and grade control step structure for grade control at exposed utility line (see photo) Remove sedimentary debris from FM 116 culverts http://www.stream.fs.fed.us/fishxing/fplibrary/Thomas_2000_Design_procedure_for_sizing_step-pool_structures.pdf		
Alternative #2:	Channel liner: concrete and/or rock riprap Remove sedimentary debris from FM 116 culverts		
Results:	Control velocity and stabilize channel Preserve exposed utility		



Cost Analysis:

TxDOT Spec No.	Item Description	Quantity	Unit	Unit Price	Total Price
	MOBILIZATION	1	LS	$30,000.00	$30,000.00
	ROCK	1,156	CY	$130.00	$150,222.22
	CONCRETE PIPE ENCASEMENT	30	LF	$100.00	$3,000.00
	DEBRIS REMOVAL	237	CY	$50.00	$11,851.85
110 6002	EXCAVATION (CHANNEL)	1,750	CY	$14.15	$24,762.50
	SWPPP	1	LS	$5,000.00	$5,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$1,000.00	$1,000.00
	ENGINEERING AND SURVEY	1	LS	25%	$56,459.14
				Total Funding for Alternative #1	$282,295.72
				35% Contingency	$98,803.50
				TOTAL	**$381,099.22**

Additional Potential Costs:
(not included in Cost Analysis)

Environmental / Permitting	Y
Easement Acquisition/Coordination	n/a
Utility Adjustments	n/a

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

City of Copperas Cove - Master Drainage Plan
Preliminary Assessment

Project Number: HC15

Project Name: Courtney Lane

Description:
City & Modeling Identified - Channel erosion and sedimentation
Crossing at Courtney Ln consists of two 6x10 Culverts which pass 10-year storm, no lateral room to add culvert
Channel experiences extremely high velocity

Alternative #1:
Natural step-pool channel design
Place grade control structures at intervals along channel from culvert under N 17th St to culvert under Courtney Ln
Initiate seasonal mow schedule to allow natural riparian buffer to form along channel banks to reduce potential for erosion
http://www.stream.fs.fed.us/fishxing/fplibrary/Thomas_2000_Design_procedure_for_sizing_step-pool_structures.pdf

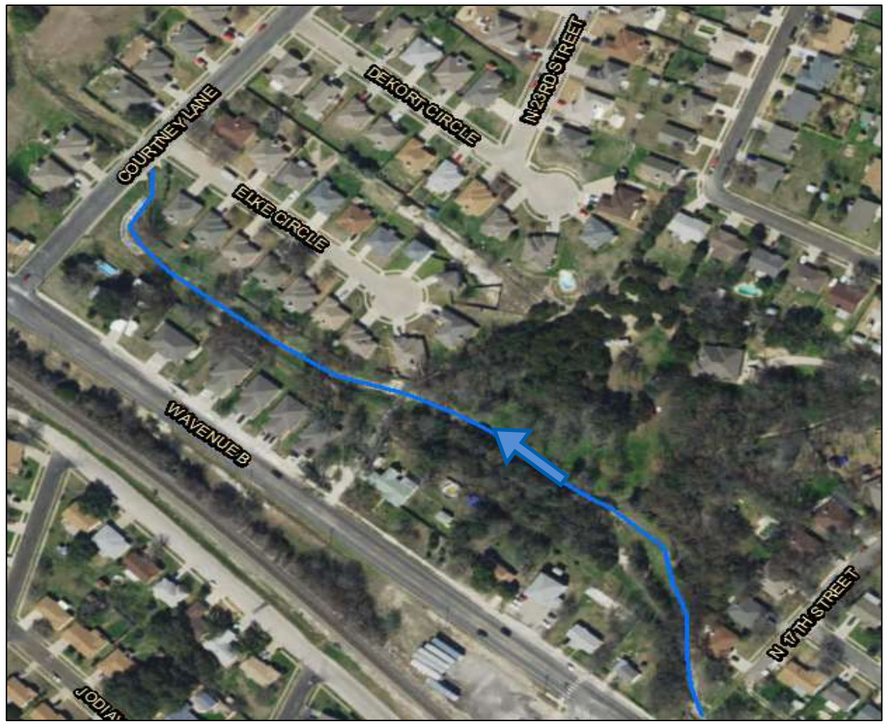
Alternative #2:
Channel liner: concrete and/or rock riprap

Results:
Control velocity and stabilize channel

Problem Type: Erosion

Location: North quadrant; Drainage ditch from Courtney Ln to N 17th St

Sources of Water: House Creek Basin



Cost Analysis:

TxDOT Spec No.	Item Description	Quantity	Unit	Unit Price	Total Price
	MOBILIZATION	1	LS	$10,000.00	$10,000.00
	ROCK	444	CY	$130.00	$57,777.78
110 6002	EXCAVATION (CHANNEL)	830	CY	$14.15	$11,739.26
	SWPPP	1	LS	$5,000.00	$5,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$1,000.00	$1,000.00
	ENGINEERING AND SURVEY	1	LS	25%	$21,379.26
				Total Funding for Alternative #1	$106,896.30
				35% Contingency	$37,413.70
				TOTAL	**$144,310.00**

Additional Potential Costs:
(not included in Cost Analysis)

Environmental / Permitting	Y
Easement Acquisition/Coordination	n/a
Utility Adjustments	n/a

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

City of Copperas Cove - Master Drainage Plan
Preliminary Assessment

Project Number: CC19

Project Name: Suja Lane

Description: City & Citizen Identified - street and property flooding at culvert at Suja Ln
2-year storm flow = 300 cfs
18" pipe capacity < 20 cfs

Solution: Re-grade channel from elevation 1118 to elevation 1104; 35-ft top width, 10-ft bottom width, 4-ft deep with 3:1 side slopes and 0.0119 longitudinal slope to carry 10-year storm
Replace southern 18" pipe with four 4' x 4' RCBs to safely pass 2-year storm

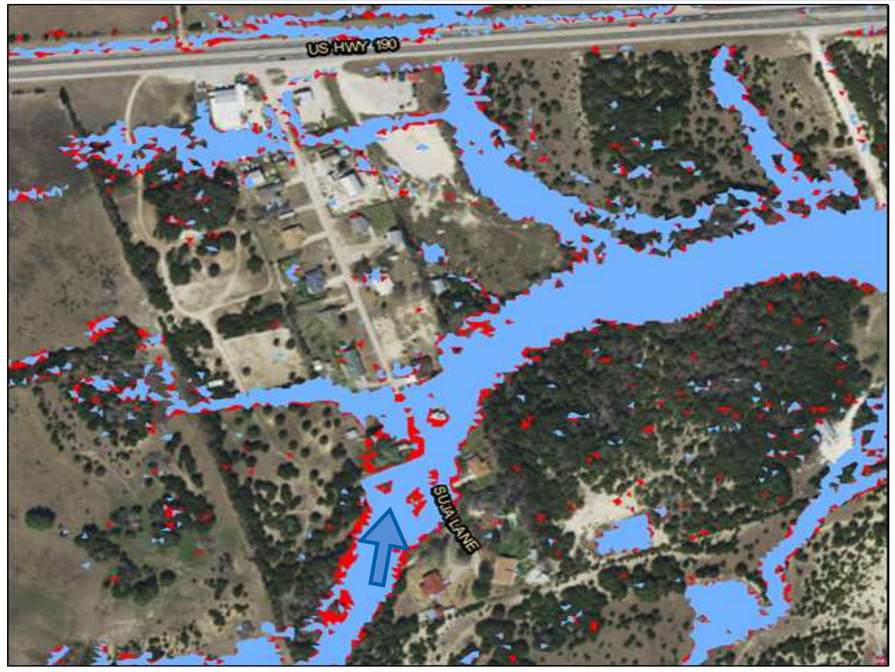
Recommendation: Mandate that proposed development to the southwest (upstream) detain any increase in runoff to maintain current drainage conditions. An alternative solution at this site might be to contribute a portion, or all, of these funds to a joint use detention facility upstream and over-detain stormwater runoff. Additional study is required to determine the effectiveness at Suja Lane.

Results: Alleviate street flooding and property flooding

Problem Type: Flooding

Location: South quadrant; Suja Ln culverts and drainage channels

Sources of Water: Clear Creek basin



* 2-Year Storm Inundation,
Existing vs Proposed Results

Cost Analysis:

TxDOT Spec No.	Item Description	Quantity	Unit	Unit Price	Total Price
	MOBILIZATION	1	LS	$30,000.00	$30,000.00
	EASEMENT/ROW ACQUISITION	1	LS	$40,000.00	$40,000.00
	STREET RECONSTRUCTION	700	SF	$20.00	$14,000.00
110 6002	EXCAVATION (CHANNEL)	3,433	CY	$14.15	$48,581.67
164 6005	BROADCAST SEED (PERM) (URBAN) (SANDY)	4,006	SY	$0.97	$3,885.39
462 6005	CONC BOX CULV FOUR (4 FT X 4 FT)	80	LF	$210.00	$16,800.00
466 6151	WINGWALL (FW - 0) (HW=4 FT)	4	EA	$6,340.00	$25,360.00
	SWPPP	1	LS	$5,000.00	$5,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$1,000.00	$1,000.00
	ENGINEERING AND SURVEY	1	LS	25%	$46,156.76
				Total Funding for Solution	$230,783.82
				35% Contingency	$80,774.34
				TOTAL	**$311,558.16**

Additional Potential Costs:
(not included in Cost Analysis)

Environmental / Permitting	Y
Easement Acquisition/Coordination	Y
Utility Adjustments	Y

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

City of Copperas Cove - Master Drainage Plan
Preliminary Assessment

Project Number:	CC17
Project Name:	Indian Camp Trail Shared Use Path
Description:	City, Citizen & Site Visit Identified - Flooding and algae growth on Shared Use Path (SUP) caused by groundwater seepage and low flow from storm drain apron (see photo) Water from backyard at 1612 Indian Camp Trail flows over SUP, contributing to algae growth
Solution: **PHASE 1**	Remove algae from concrete, then seal concrete, include anti-skid additive http://www.homedepot.com/p/Eagle-5-gal-Natural-Seal-Penetrating-Clear-Water-Based-Concrete-and-Masonry-Water-Repellant-Sealer-and-Salt-Repellant-EM5/203075976 http://www.homedepot.com/p/Seal-Krete-3-2-oz-Clear-Grip-Anti-Skid-Additive-402002/203002764
Solution: **PHASE 2**	If Phase 1 does not alleviate safety hazard, then: Install V-notch concrete ditch from backyard at 1612 Indian Camp Trail and at joint between baffle apron and SUP parallel to SUP, then across SUP, then outfall to creek Cover portion of ditch perpendicular to SUP with trench grate
Results:	Reduce slipping/falling hazard on SUP

Problem Type:	Safety
Location:	South quadrant; Shared Use Path behind 1612 Indian Camp Trail
Sources of Water:	Clear Creek basin

Cost Analysis:

TxDOT Spec No.	Item Description	Quantity	Unit	Unit Price	Total Price
	POWER WASHING	1	LS	$500.00	$500.00
	CONCRETE SEALANT	2	5 GAL	$79.97	$159.94
	ANTI-SKID SEALANT ADDITIVE	6	3.2 OZ	$8.88	$53.28
	LABOR / INSTALLATION	1	LS	$1,000.00	$1,000.00
				35% Contingency	$599.63
				Total Funding for PHASE 1	**$2,312.85**
	MOBILIZATION	1	LS	$1,000.00	$1,000.00
	GRATE (EAST JORDAN) (12 IN X 24 IN)	6	EA	$85.00	$510.00
104 6015	REMOVING CONC (SIDEWALKS)	8	SY	$12.30	$102.50
110 6002	EXCAVATION (CHANNEL)	3	CY	$14.15	$39.31
432 2002	RIPRAP (CONC)(5 IN)	3	CY	$550.00	$1,527.78
	SWPPP	1	LS	$5,000.00	$5,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$250.00	$250.00
				35% Contingency	$2,950.35
				Total Funding for PHASE 2	**$11,379.94**

Additional Potential Costs:
(not included in Cost Analysis)

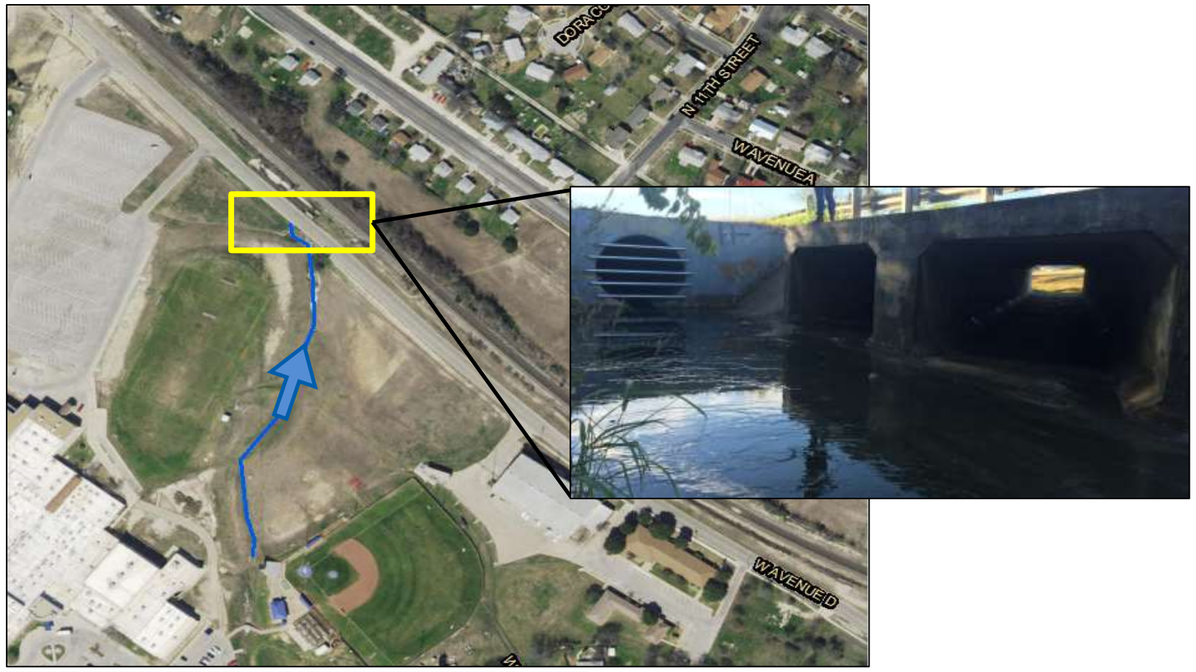
Environmental / Permitting	n/a
Easement Acquisition/Coordination	n/a
Utility Adjustments	n/a

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

City of Copperas Cove - Master Drainage Plan
Preliminary Assessment

Project Number:	HC11
Project Name:	Avenue D
Description:	City & Modeling Identified - Street flooding at culvert crossing, upstream channel erosion, baseball field flooding 10-year storm channel velocity = 5.5 ft/sec Street Culverts (W Avenue D) capacity (two 6 x 4 RCBs) = 420 cfs < 10-year storm (see photo) Railroad Culvert capacity (10 x 8 RCB) > 100-year storm
Solution:	Add one 4 x 4 RCB next to existing culvert (safely pass 10-year storm) Regrade channel (shown in blue) to 45-ft top width, 25-ft bottom width, 4:1 side slopes, 2.5 feet deep to carry 10-year storm; add soil retention blanket, re-seed
Results:	Preserve channel next to sports fields and reduce flooding upstream of W Avenue D without causing adverse impact downstream of Railroad
Problem Type:	Flooding and Erosion
Location:	North quadrant; Culvert under 707 W Avenue D and ditch upstream to baseball field
Sources of Water:	House Creek Basin



Cost Analysis:

TxDOT Spec No.	Item Description	Quantity	Unit	Unit Price	Total Price
	MOBILIZATION	1	LS	$13,000.00	$13,000.00
	STREET RECONSTRUCTION	1,200	SF	$20.00	$24,000.00
110 6002	EXCAVATION (CHANNEL)	2,022	CY	$14.15	$28,614.44
164 6005	BROADCAST SEED (PERM) (URBAN) (SANDY)	4,200	SY	$0.97	$4,074.00
169 6002	SOIL RETENTION BLANKETS (CL 1) (TY B)	4,200	SY	$2.45	$10,290.00
462 6005	CONC BOX CULV (4 FT X 4 FT)	35	LF	$210.00	$7,350.00
	SWPPP	1	LS	$5,000.00	$5,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$1,000.00	$1,000.00
	ENGINEERING AND SURVEY	1	LS	25%	$23,332.11
				Total Funding for Solution	$116,660.56
				35% Contingency	$40,831.19
				TOTAL	**$157,491.75**

Additional Potential Costs:
(not included in Cost Analysis)

Environmental / Permitting	n/a
Easement Acquisition/Coordination	n/a
Utility Adjustments	n/a

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

City of Copperas Cove - Master Drainage Plan
Preliminary Assessment

Project Number: TR19

Project Name: January Street

Description: Citizen Identified - Property flooding & erosion of flume between homes
High point in flume close to street (see blue line)

Solution: Re-grade flume to remove high point
Line flume with concrete to produce 10 ft wide, 0.5 ft deep rectangular section

Results: Alleviate property flooding and erosion
Achieve design uniformity with other flumes between properties in the area

Problem Type: Flooding and Erosion

Location: East quadrant; Earthen drainage flume at 224 January St

Sources of Water: Turkey Run basin

Cost Analysis:

TxDOT Spec No.	Item Description	Quantity	Unit	Unit Price	Total Price
	MOBILIZATION	1	LS	$2,500.00	$2,500.00
110 6002	EXCAVATION (CHANNEL)	44	CY	$14.15	$628.89
	RIPRAP (CONC)(5 IN)	23	CY	$650.00	$14,925.93
	SWPPP	1	LS	$3,000.00	$3,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$250.00	$250.00
				Total Funding for Solution	$21,304.81
				35% Contingency	$7,456.69
				TOTAL	**$28,761.50**

Additional Potential Costs:
(not included in Cost Analysis)

Environmental / Permitting	n/a
Easement Acquisition/Coordination	n/a
Utility Adjustments	n/a

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

City of Copperas Cove - Master Drainage Plan
Preliminary Assessment

Project Number: HC07

Project Name: Avenue B

Description: Citizen Identified - Grate inlet covered in gravel from construction.
Localized flooding due to insufficient ditch conveyance and inlet blockage.

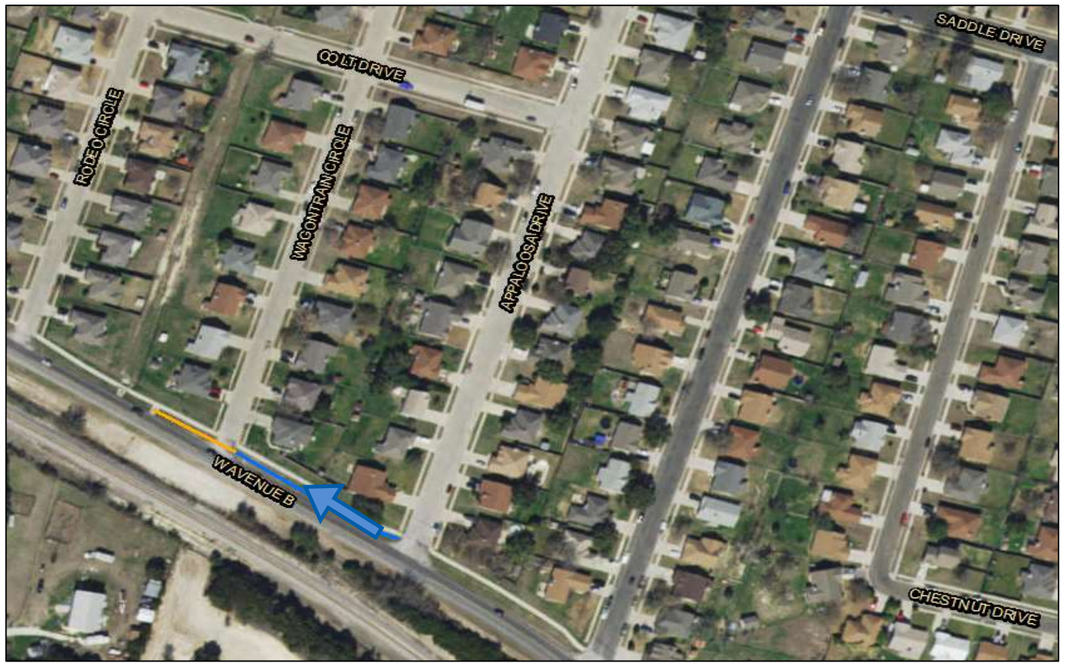
Solution: Re-grade ditch from Appaloosa to Wagontrain (shown in blue) to a 12-ft v-ditch with 3:1 side slopes, from flowline elevation 1082.5 to elevation 1079.5, to safely pass 25-year storm
Place two 24" RCPs under Wagontrain to discharge at grate inlet (shown in orange)
Replace existing grate with grate with larger openings to reduce inlet blockage

Results: Alleviate street flooding

Problem Type: Flooding

Location: North quadrant; Drainage ditch on W Avenue B from Wagontrain Circle to Appaloosa Dr

Sources of Water: House Creek basin



Cost Analysis:

TxDOT Spec No.	Item Description	Quantity	Unit	Unit Price	Total Price
	MOBILIZATION	1	LS	$5,000.00	$5,000.00
	GRATE	1	EA	$800.00	$800.00
110 6002	EXCAVATION (CHANNEL)	200	CY	$14.15	$2,830.00
164 6005	BROADCAST SEED (PERM) (URBAN) (SANDY)	600	SY	$0.97	$582.00
464 2007	RC PIPE (CL III)(24 IN)	70	LF	$70.00	$4,900.00
467 6417	SET (TY II) (24 IN) (RCP) (3: 1)	2	EA	$2,100.00	$4,200.00
	SWPPP	1	LS	$5,000.00	$5,000.00
	TRAFFIC CONTROL	1	LS	$15,000.00	$15,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$1,000.00	$1,000.00
	ENGINEERING AND SURVEY	1	LS	25%	$9,828.00
				Total Funding for Solution	$49,140.00
				35% Contingency	$17,199.00
				TOTAL	**$66,339.00**

Additional Potential Costs:
(not included in Cost Analysis)

Environmental / Permitting	n/a
Easement Acquisition/Coordination	n/a
Utility Adjustments	Y

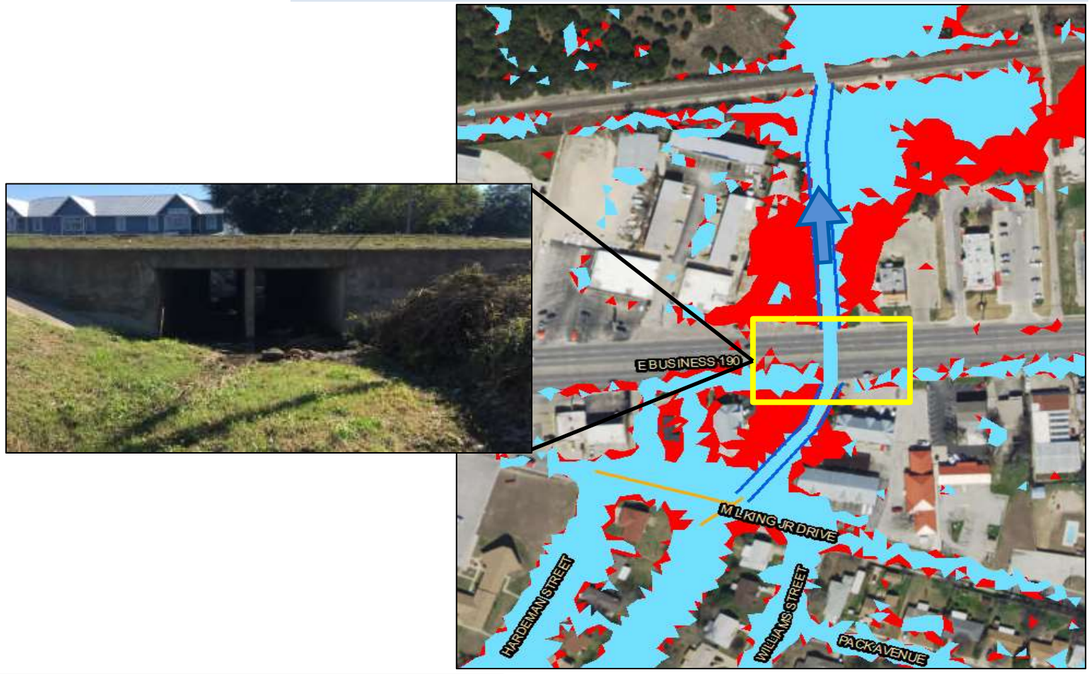
Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

City of Copperas Cove

City of Copperas Cove - Master Drainage Plan
Preliminary Assessment

Project Number:	TR12
Project Name:	MLK
Description:	Citizen, City and Modeling Identified - Street and Property Flooding. MLK Culvert capacity = 50 cfs < 10-year storm US 190 Culvert capacity = 650 cfs > 25-year storm (see photo) Railroad Culvert capacity = 415 cfs < 10-year storm Inlets on Hardeman St and Williams St have negative flow due to surcharging from channel
Solution:	Replace 36" pipes perpendicular to MLK with two 5x3 ft RCB (yellow line) Add one 20-ft inlet on MLK near Hardeman and replace 36" RCP under MLK with 5x3 RCB (yellow line) Re-grade channels (remove trees) from MLK to US 190 and US 190 to Railroad to 22-ft top width, 10-ft bottom width, 1:1 side slope concrete-lined section to carry 25-year storm plus freeboard
Results:	Reduces flood extents on US 190 for 25-year storm Reduces length of time MLK is flooded above 6 inches by 40 minutes for 10- and 25-year storms Reduces length of time MLK is flooded above 12 inches by 45 minutes for 25-year storm Removes surcharging from inlets in vicinity for 10- and 25-year storms

Problem Type:	Flooding
Location:	East quadrant; 809 Martin Luther King Jr Dr from Hardeman St to Williams St
Sources of Water:	Turkey Run basin; Copperas Cove High School area to the south



* 10-Year Storm Inundation,
Existing vs Proposed Results

Cost Analysis:

TxDOT Spec No.	Item Description	Quantity	Unit	Unit Price	Total Price
	MOBILIZATION	1	LS	$60,000.00	$60,000.00
	STREET RECONSTRUCTION	3,400	SF	$20.00	$68,000.00
110 6002	EXCAVATION (CHANNEL)	1,244	CY	$14.15	$17,608.89
432 2002	RIPRAP (CONC)(5 IN)	270	CY	$550.00	$148,533.95
462 6007	CONC BOX CULV (5 FT X 3 FT)	310	LF	$250.00	$77,500.00
464 2009	RC PIPE (CL III)(36 IN)	45	LF	$105.00	$4,725.00
465 6180	INLET (COMPL)(CURB)	1	EA	$9,000.00	$9,000.00
466 6181	WINGWALL (PW - 1) (HW=6 FT)	1	EA	$13,700.00	$13,700.00
467 61XX	SET (TY I)(HW=3FT)	2	EA	$6,000.00	$12,000.00
	SWPPP	1	LS	$5,000.00	$5,000.00
	TRAFFIC CONTROL PLAN	1	LS	$25,000.00	$25,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$1,000.00	$1,000.00
	ENGINEERING AND SURVEY	1	LS	25%	$110,516.96
				Total Funding for Solution	$552,584.80
				35% Contingency	$193,404.68
				TOTAL	**$745,989.48**

Additional Potential Costs:
(not included in Cost Analysis)

Environmental / Permitting	Y
Easement Acquisition/Coordination	Y
Utility Adjustments	Y

City of Copperas Cove

City of Copperas Cove - Master Drainage Plan
Preliminary Assessment

Project Number: CC02

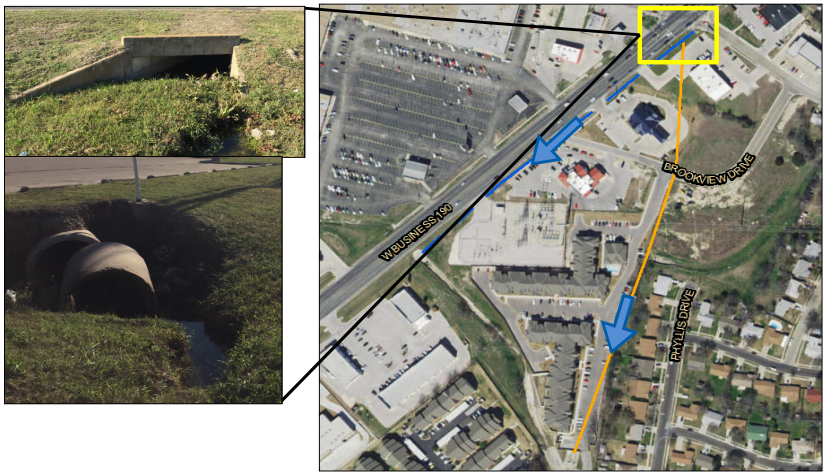
Problem Type: Flooding

Project Name: US 190

Location: South quadrant; 101 US 190; Storm Sewer Inlet under Auto Zone

Description: City & Site Visit Identified - Channel erosion and sedimentation in storm sewer system; the city has re-attached the 36" RCP section that was broken off (see bottom photo)
US 190 Driveway culverts capacity = 20 cfs < 10-year storm
36" RCP flowing North to South (yellow line) has capacity for 25-year storm but is not functioning at optimum conveyance, thus contributing to driveway flooding (shown in orange)
RCB flowing south from Main St toward 36" RCP (see top photo)

Sources of Water: Clear Creek basin; S Main St system; US 190 system



Solution:
PHASE 1
Place headwall with wingwalls around 36" RCP
Remove sediment from RCB outfall
Regrade area between RCB outfall and RCP inlet; add concrete pilot channel

Solution:
PHASE 2
If Phase 1 does not aleviate flooding, then:
Regrade channel from elevation 1082 at intersection with Leonhard St to elevation 1066 at main channel, with 1 ft bottom width, 3:1 side slopes, and 13 ft top width to carry 25-year storm (shown in blue). Replace driveway culverts at industrial complex with 2 - 24" RCPs to safely pass 25-year storm.

Results:
Optimize conveyance of 36" RCP
Reduce street flooding

Cost Analysis:

TxDOT Spec No.	Item Description	Quantity	Unit	Unit Price	Total Price
	MOBILIZATION	1	LS	$2,500.00	$2,500.00
	DEBRIS REMOVAL	15	CY	$50.00	$750.00
110 6002	EXCAVATION (CHANNEL)	25	CY	$14.15	$353.75
164 6005	BROADCAST SEED (PERM) (URBAN) (SANDY)	111	SY	$0.97	$107.78
432 2002	RIPRAP (CONC)(5 IN)	3	CY	$550.00	$1,442.90
466 61XX	HEADWALL (CH-FW-S) (DIA= 36 IN)	1	EA	$8,500.00	$8,500.00
	SWPPP	1	LS	$5,000.00	$5,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$1,000.00	$1,000.00
	ENGINEERING AND SURVEY	1	LS	25%	$4,913.61
				35% Contingency	$8,598.81
				Total Funding for PHASE 1	**$33,166.85**
	MOBILIZATION	1	LS	$5,000.00	$5,000.00
110 6002	EXCAVATION (CHANNEL)	368	CY	$14.15	$5,213.23
164 6005	BROADCAST SEED (PERM) (URBAN) (SANDY)	1,442	SY	$0.97	$1,398.42
464 2022	RC PIPE (CL IV)(24 IN)	370	LF	$71.00	$26,270.00
	SWPPP	1	LS	$5,000.00	$5,000.00
	PUBLIC NOTIFICATION / SIGNAGE	1	LS	$1,000.00	$1,000.00
	ENGINEERING AND SURVEY	1	LS	25%	$10,970.41
				35% Contingency	$19,198.22
				Total Funding for PHASE 2	**$74,050.27**

Additional Potential Costs:
(not included in Cost Analysis)

Environmental / Permitting	n/a
Easement Acquisition/Coordination	n/a
Utility Adjustments	Y

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Appendix C – Supporting Information (DVD)

Exhibits

Final Report

Geodatabase

ICM Results

Proposed CIP solutions